CALIBRATION PROCEDURE
NI PXIe-4353

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This document contains information about verifying and adjusting National Instruments NI PXIe-4353 modules using NI-DAQmx 9.3 and later. It also contains information about verifying systems that include both the NI PXIe-4353 and TB-4353. For more information about calibration, visit ni.com/calibration.

Contents

Software 1
Documentation 2
Calibration Interval 2
Test Equipment 2
Test Conditions 3
NI PXIe-4353 Calibration Procedure 3
    Initial Setup for the NI PXIe-4353 4
    Verifying Module Operating Temperature Changes 4
    Verification Procedure 5
        Analog Input Voltage Accuracy Verification 5
        Analog Input Offset Verification 7
        CJC Resistance Accuracy Verification 8
    Module Calibration Adjustment 10
Test Limits 13
    Module Verification Test Limit Tables 13
Where to Go for Support 15

Software

Install NI-DAQmx 9.3 or later on the calibration computer. NI-DAQmx includes high-level function calls to simplify the task of writing software to calibrate modules. You must have the proper module driver installed on the calibration system before calibrating the module.

Note NI recommends that you install the NI-DAQmx driver software before physically installing the NI PXIe-4353. NI-DAQmx, available at ni.com/downloads, configures and controls the NI PXIe-4353.

NI-DAQmx supports a number of programming languages, including LabVIEW, LabWindows™/CVI™, C/C++, C#, and Visual Basic .NET.

You can access the NI-DAQmx header file, NIDAQmx.h, like any standard library. You can find examples of how to use the NI-DAQmx driver by entering the Info Code NIDAQmxExLoc at ni.com/info there you will find the topic *Where Can I Find NI-DAQmx Examples?*

NATIONAL INSTRUMENTS

Documentation

The following documents are your primary references for writing your calibration utility with NI-DAQmx. You can download the latest version of these documents from the NI Web site at `ni.com/manuals`.

- The *NI SC Express 4353 Installation Guide and Terminal Block Specifications* provides instructions for installing and configuring the NI PXIe-4353 module and TB-4353 accessory.
- The *NI PXIe-4353 User Manual* describes how to use the NI PXIe-4353.
- The *NI PXIe-4353 Specifications* lists the specifications for the NI PXIe-4353.
- The *CAL-4353 Specifications* lists the specifications for the CAL-4353.
- The *NI-DAQmx Help* includes information about creating applications that use the NI-DAQmx driver.
- The *NI-DAQmx C Reference Help* includes information about the functions in the driver.

Calibration Interval

National Instruments recommends a calibration interval of one year for the NI PXIe-4353. You should adjust the recommended calibration interval based on the measurement accuracy demands of your application.

Test Equipment

National Instruments recommends that you use the instruments in Table 1 for calibrating an NI PXIe-4353 module.

Table 1. Recommended Equipment

Equipment	Recommended Model	Requirements
Voltage calibrator	Fluke 5520A	If this instrument is unavailable for voltage accuracy verification and adjustment, use a high-precision voltage source with an accuracy of at least 70 ppm when sourcing up to 50 μA.
Resistance calibrator*	Fluke 5520A	If this instrument is unavailable for resistance accuracy verification and adjustment, use a high-precision resistance source with an accuracy of at least 150 ppm 2-wire compensation. If the resistance source does not have 2-wire compensation, the lead wire resistance must be included in the total resistance source accuracy.
PXI Express chassis	NI PXIe-1062Q	—
Calibration accessory	CAL-4353	This accessory is used for module verification and adjustment.
Connecting wires	Banana-jack terminated copper wire	Copper wire is used for validating the voltage accuracy and adjustment of the analog input channels. Copper wire is also used for validating the resistance accuracy and calibration of the CJC resistance input channels.

* When connecting the resistance calibrator, keep the lead wires 1.0 Ω less than the maximum lead compensation specification of the resistance calibrator. When using the Fluke 5520A, keep the lead wires <1.1 Ω.

Test Conditions

The following setup and environmental conditions are required to ensure the module meets published specifications.

- Keep connections to the module as short as possible. Long cables and wires act as antennas, picking up extra noise that can affect measurements.
- Use shielded wire for all cable connections to the module. Use twisted-pair wire to eliminate noise.
- Maintain an ambient temperature of 23 °C ±5 °C. The module temperature will be greater than the ambient temperature.
- Keep relative humidity below 80%.
- Allow a warm-up time of 15 minutes to ensure that the measurement circuitry of the NI PXIe-4353 and CAL-4353 are at a stable operating temperature.

Note If you are using the Fluke 5520A, allow the calibrator to warm up for 30 minutes and maintain an ambient temperature of 23 °C ±3 °C.[1]

- Ensure that the PXI Express chassis fan speed is set to HIGH, that the fan filters are clean, and that the empty slots contain filler panels. For more information, refer to the *Maintain Forced-Air Cooling Note to Users* document available at `ni.com/manuals`.

NI PXIe-4353 Calibration Procedure

This section provides instructions for verifying the voltage accuracy performance of the NI PXIe-4353. The calibration process consists of the following steps:

1. *Initial Setup for the NI PXIe-4353*—Install the module and configure it in Measurement & Automation Explorer (MAX).
2. *Verifying Module Operating Temperature Changes*—Verify that the current module operating temperature will not cause you to incorrectly calibrate your module.
3. *Verification Procedure*—Verify the existing operation of the module. This steps confirms whether the module is operating within its specified range and whether it needs adjustment.
4. *Adjustment*—If the module does not fall within the desired specifications, perform the adjustment procedure. This will adjust the module calibration constants. If the module does fall within the desired specifications, but the module has reached its calibration time interval since the last calibration adjustment, perform the adjustment procedure. Otherwise, performing the adjustment procedure is optional.
5. *Reverification*—Repeat the verification procedure to ensure that the module is operating within the published specifications after adjustment.

The first four steps are explained in the following sections.

[1] Refer to the Fluke 5520A user manual for the latest set up requirements and recommendations to achieve the best accuracy.

Initial Setup for the NI PXIe-4353

You must configure the module in Measurement & Automation Explorer (MAX) to communicate with NI-DAQmx.

Complete the following steps to configure a module in MAX. Refer to the *NI SC Express 4353 Installation Guide and Terminal Block Specifications* for complete installation instructions.

1. Install the NI-DAQmx driver software.

Caution Always have the PXI Express chassis powered off when inserting a module.

2. Insert the module into an available slot in the PXI Express chassis.
3. Attach the CAL-4353 to the NI PXIe-4353.

Note The CAL-4353 must be within its calibration interval and if it is not, you must calibrate the CAL-4353 before calibrating the NI PXIe-4353 module.

4. Power on the chassis.
5. Launch MAX.
6. Expand **Devices and Interfaces** to confirm that MAX detects the module and terminal block. The terminal block should appear beneath its associated module.
7. Right-click **NI PXIe-4353** and select **Self-Test** to ensure that the module is working properly.

Note You can also perform the self-test operation programmatically, using the DAQmx Self-Test Device VI or the equivalent C/.NET functionality.

Verifying Module Operating Temperature Changes

A module operating temperature greater than ±10 °C since the previous calibration adjustment can cause you to incorrectly calibrate your module. The onboard temperature sensor on the module can be used to verify that this condition does not exist. Complete the following steps to compare the current module temperature to the temperature measured during the last calibration.

1. Launch MAX.
2. Select **My System»Devices and Interfaces»Chassis 1»NI PXIe-4353**.

Note MAX assigns a chassis name for each chassis in an application. This document uses Chassis 1. In your application, use the appropriate name assigned to your chassis by MAX.

3. Click the **Calibration** tab.

   If the difference between the current operating temperature and the operating temperature from the last calibration adjustment is greater than 10 °C, the limits in the calibration tables are not valid.

Note You can also query the temperatures programmatically, using the DAQmx Calibration Info property node or the equivalent C/.NET functionality.

Note The temperature reading returned by the module is an internal temperature. Typically, the internal temperature is approximately 10 °C warmer than the ambient temperature.

If the module temperature difference is outside the maximum range, you should choose one of the following options:

- Recalculate the test limits to include the additional error due to temperature drift. Refer to the *NI PXIe-4353 Specifications* for more information.
- Change the system so that the operating temperature will be closer to the temperature recorded during the last calibration adjustment.

Verification Procedure

This section provides instructions for verifying the NI PXIe-4353 specifications.

Tables 4 through 7 in the *Test Limits* section show all acceptable settings for the module. Throughout the verification process, use Tables 4 through 7 to determine if the module is operating within its specified range. Perform verification on all analog input and CJC channels.

Analog Input Voltage Accuracy Verification

Complete the following steps to test the voltage accuracy performance of the module.

1. Using banana-jack terminated copper wire, connect the positive and negative terminals of the voltage calibrator to the terminals labeled INPUT V Ω HI and LO of the CAL-4353 while referring to Figure 1.

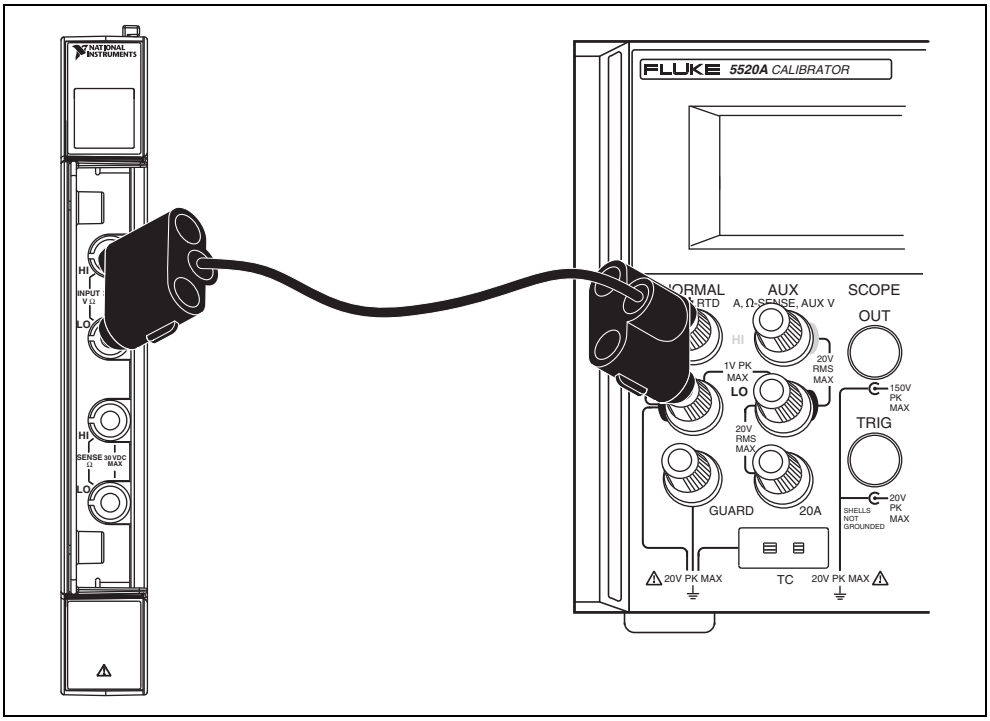


Figure 1. CAL-4353 to Fluke 5520A Calibrator Connections

2. Open a DAQmx calibration session on your device.
3. Call the DAQmx Connect SC Express Calibration Accessory Channels VI. Configure the CAL-4353 by setting the connection to `_tc_calibration` and the physical channels to `Dev1/ai0:31`.

Note When MAX configures a module, it is assigned a module name. Each function call uses this module name to determine the correct module to adjust. This document uses `Dev1` when referring to the module name. When you calibrate your module, use the module name assigned to it by MAX.

4. If you are not using a Fluke 5520A, set the calibrator voltage to a Test Point value indicated in Table 4.

5. To reduce the loading error when using a Fluke 5520A, set the voltage range to 3.3 V as follows:
   a. On the front panel, set the output voltage to 2.0 V.
   b. Press the **3.3 V Auto** button, which will display 3.3 V locked. The output will no longer auto-range.
   c. Set the output to the desired voltage level using Table 4.
6. Create and configure AI voltage channels you want to verify.
7. Set the autozero mode to Every Sample and disable open thermocouple detection.
8. On the DAQmx Channel property node, set the DAQmx ADC timing mode property to Custom and set the ADC custom timing mode property to a value from the first column of Table 4. To determine which timing mode to select, use Table 4.
9. Configure the timing properties for a finite voltage acquisition. Refer to Table 2.

Table 2. DAQmx Timing Function Rate and Samples per Channel

Timing Mode	Rate (S/s)	Samples per Channel
1	1	16
2	2	16
3	4	20
4	8	40
5	16	80
6	32	120
7	90	300

10. Start the acquisition.

11. Acquire the voltage data.

Note Make sure the calibrator and the NI PXIe-4353 are completely settled at the desired voltage before acquiring data. When using the Fluke 5520A, wait at least 5000 ms for the system to settle before issuing the start task command to the NI PXIe-4353.

Note You must set the read timeout value to something larger than the default, such as 20.0 seconds, or you will get a timeout error.

12. Average the voltage values for each channel that you acquired. Compare the resulting average to the *Upper Limit* and *Lower Limit* values in Table 4. If the result is between these values, the module passes the test.
13. Clear the acquisition.
14. Repeat steps 4 through 13 for all test point values in Table 4. NI recommends that you verify all values, although you can save time by verifying only the values used in your application.
15. Close the DAQmx calibration session with the action Cancel.
16. Disable the calibrator output and disconnect the calibrator from the module.

Analog Input Offset Verification

Complete the following steps to test the performance of the analog input offset of the module.

1. Open a DAQmx calibration session on your device.
2. Call the DAQmx Connect SC Express Calibration Accessory Channels VI. Configure the CAL-4353 by setting the connection to `_short_tc_terminals` and the physical channels to `Dev1/ai0:31`.
3. Set voltage calibrator output to 0 V.
4. Complete steps 6 through 13 of the *Analog Input Voltage Accuracy Verification* section to test the performance of analog input offset of the module. Repeat these steps for all timing modes.
5. Compare the resulting average to the *Upper Limit* and *Lower Limit* offset values in Table 5. NI recommends that you verify all values, although you can save time by verifying only the values used in your application.
6. Repeat steps 6 through 13 of the *Analog Input Voltage Accuracy Verification* section with autozero mode set to None in step 7. Repeat these steps for all timing modes.
7. Compare the resulting average to the *Upper Limit* and *Lower Limit* offset values in Table 6. NI recommends that you verify all values, although you can save time by verifying only the values used in your application.
8. Close the DAQmx calibration session with the action Cancel.

Note After verifying your module, you can update the last calibration date by opening a DAQmx external calibration session and closing it with the action Commit.

CJC Resistance Accuracy Verification

Complete the following steps to test the CJC resistance accuracy performance of the module.

1. Using banana-jack terminated copper wire, connect the positive and negative terminals of the resistance calibrator to the INPUT V Ω HI and LO inputs of the CAL-4353. Also connect the SENSE Ω HI and LO terminals of the CAL-4353 to the Sense HI and LO terminals of the resistance calibrator while referring to Figure 2.
2. Set the resistance calibrator to 2-wire compensation mode.

Note When using the Fluke 5520A, set the calibrator to 2-WIRE COMP mode.

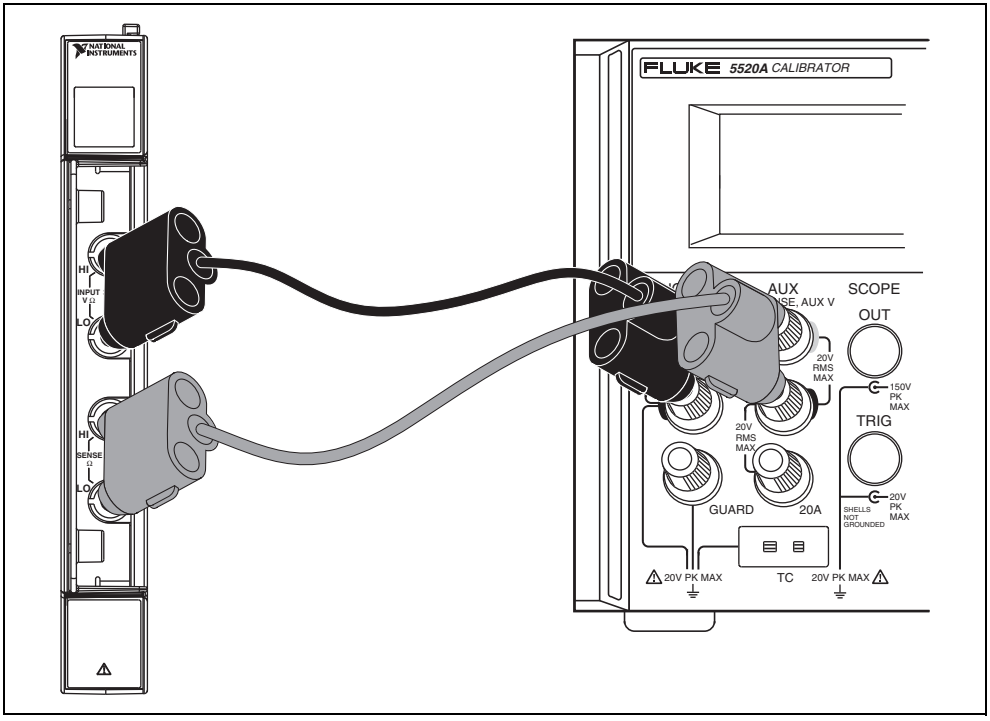


Figure 2. CAL-4353 to Fluke 5520A Calibrator Connections

3. Open a DAQmx calibration session on your device.
4. Call the DAQmx Connect SC Express Calibration Accessory Channels VI. Configure the CAL-4353 by setting the connection to `_cjc_calibration` and the physical channels to the CJC channel you want to verify.

Note Qualify the CJC channel name by the device name. For example, the physical channel name must have the format `Dev1/_cjtemp0`.

5. Set the calibrator resistance to a Test Point value indicated in Table 7.
6. Create and configure the CJC channel for voltage acquisition.
7. Set the ADC timing mode property to Custom and set the ADC custom timing mode property to a value from the first column of Table 3. Use Table 3 to determine which timing mode to select.

8. Configure the timing properties for the voltage acquisition. Refer to Table 3.

Table 3. DAQmx Timing Function Rate and Samples per Channel for CJC Verification

Timing Mode	Rate (S/s)	Samples per Channel
1	17	10
2	34	10
3	68	20
4	90	35
5	90	50
6	90	80
7	90	150

9. Start the acquisition.
10. Acquire the voltage data.

Note Make sure that the calibrator and the NI PXIe-4353 are completely settled on the desired resistance before acquiring data. When using the Fluke 5520A, wait at least 5000 ms for the system to settle before issuing the start task function to the NI PXIe-4353.

11. Calculate the equivalent resistance using the following equation:

$$R_{CJC} = \frac{40\ \text{k}\Omega}{\frac{2.048\ \text{V}}{V_{CJC_ave}} - 1}$$

where V_{CJC_ave} is the average of the voltage values for the channel you acquired.

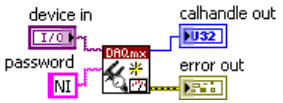
12. Compare the resulting average to the *Upper Limit* and *Lower Limit* values in Table 7. If the result is between these values, the channel passes the test.
13. Clear the acquisition.
14. Repeat steps 5 through 12 for all CJC channels and test point values in Table 7. NI recommends that you verify all values, although you can save time by verifying only the values used in your application.
15. Close the DAQmx calibration session with the action Cancel.
16. Disable the calibrator output and disconnect the calibrator from the CAL-4353.

Note After verifying your module, you can update the last calibration date by opening a DAQmx external calibration session and closing it with the action Commit.

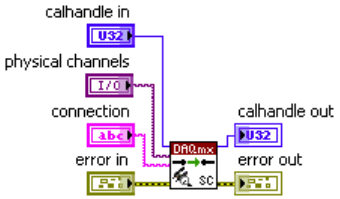
Module Calibration Adjustment

Complete the following steps to adjust the input voltage and CJC resistance calibration constants of the module.

1. Using banana-jack terminated copper wire, connect the positive and negative terminals of the INPUT V Ω HI and LO terminals of the CAL-4353 to the Fluke 5520A or equivalent calibrator. Connect the SENSE Ω HI and LO terminals of the CAL-4353 to the calibrator Sense HI and LO terminals while referring to Figure 2.
2. Open a calibration session on your module using the DAQmx Initialize External Calibration VI. The default password is `NI`.

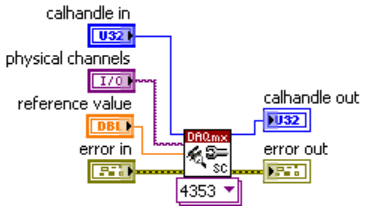
LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxInitExtCal` with the following parameters: **deviceName**: `Dev1` **password**: `NI` **calHandle**: `&calHandle`

3. Configure the CAL-4353 using the DAQmx Connect SC Express Calibration Accessory Channels VI. Set the connection to `_tc_calibration` and the physical channels to `Dev1/ai0:31`.

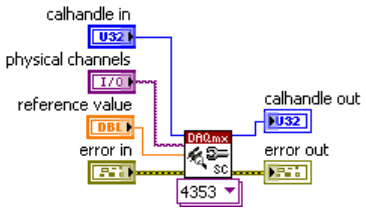
LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxConnectSCExpressCalAccChans` with the following parameters: **calHandle**: `calHandle` **channelNames**: `Dev1/ai0:31` **connection**: `_tc_calibration`

4. Set the calibrator to output +70 mV and wait for the calibrator output to settle.
5. To reduce the loading error when using a Fluke 5520A, set the voltage range to 3.3 V as follows:
   a. On the front panel, set the output voltage to 2.0 V.
   b. Press the **3.3 V Auto** button, which will display 3.3 V locked. The output will no longer auto-range.
   c. Set the output to the desired voltage level using Table 4.

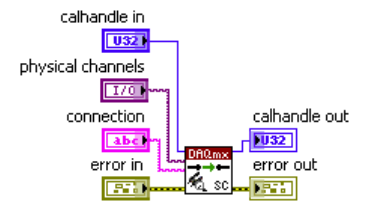
6. Perform an external calibration adjustment by selecting the DAQmx Adjust 4353 Calibration VI, from the DAQmx Adjust SC Express Calibration polymorphic VI. Set the physical channels to `Dev1/ai0:1`. The reference value parameter is the actual output of the calibrator, 70 mV.

LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxAdjust4353Cal` with the following parameters: **calHandle**: `calHandle` **channelNames**: `Dev1/ai0:1` **refVal**: actual output of the calibrator

7. Set the calibrator to output –70 mV and wait for the calibrator output to settle.
8. Perform an external calibration adjustment by selecting the DAQmx Adjust 4353 Calibration VI, from the DAQmx Adjust SC Express Calibration polymorphic VI. Set the physical channels to `Dev1/ai0:1`. The reference value parameter is the actual output of the calibrator, –70 mV.

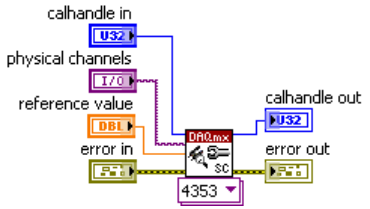
LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxAdjust4353Cal` with the following parameters: **calHandle**: `calHandle` **channelNames**: `Dev1/ai0:1` **refVal**: actual output of the calibrator

9. Disable the calibrator output.
10. Set the resistance calibrator to 2-wire compensation mode.
11. Configure the CAL-4353 using the DAQmx Connect SC Express Calibration Accessory Channels VI. Set the connection to `_cjc_calibration` and the physical channels to `Dev1/_cjtemp0`.

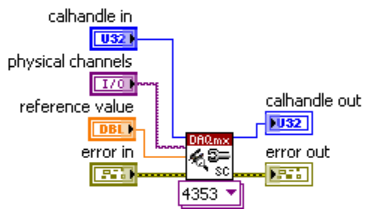
LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxConnectSCExpressCalAccChans` with the following parameters: **calHandle**: `calHandle` **channelNames**: `Dev1/_cjtemp0` **connection**: `_cjc_calibration`

12. Set the calibrator to resistance mode. Set the calibrator resistance to 32.4 kΩ and wait for the calibrator output to settle.

13. Perform an external calibration adjustment by selecting the DAQmx Adjust 4353 Calibration VI, from the DAQmx Adjust SC Express Calibration polymorphic VI. Set the physical channels to `Dev1/_cjtemp0`. The reference value parameter is the actual output of the calibrator, 32.4 kΩ.

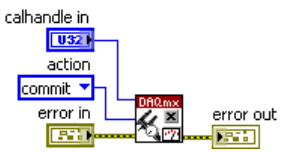
LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxAdjust4353Cal` with the following parameters: **calHandle**: `calHandle` **channelNames**: `Dev1/_cjtemp0` **refVal**: actual output of the calibrator

14. Set the calibrator resistance to 0 Ω and wait for the calibrator output to settle.
15. Perform an external calibration adjustment by selecting the DAQmx Adjust 4353 Calibration VI, from the DAQmx Adjust SC Express Calibration polymorphic VI. Set the physical channels to `Dev1/_cjtemp0`. The reference value parameter is the actual output of the calibrator, 0 Ω.

LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxAdjust4353Cal` with the following parameters: **calHandle**: `calHandle` **channelNames**: `Dev1/_cjtemp0` **refVal**: actual output of the calibrator

16. Disable the calibrator output.
17. Save the adjustment constants to the EEPROM, using the DAQmx Close External Calibration VI and set the action to Commit. This VI also saves the date, time, and temperature of the adjustment to the onboard memory.

Note If an error occurs during adjustment, no constants will be written to the EEPROM.

LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxCloseExtCal` with the following parameters: **calHandle**: `calHandle` **action**: `DAQmx_Val_Action_Commit`

18. Disconnect the calibrator from the module.

Note Partial adjustment of only the TC channels is possible by omitting steps 10 through 16. Partial adjustment of only the CJC channels is possible by omitting steps 3 through 9.

Test Limits

Tables 4 through 7 list the specifications that the NI PXIe-4353 module or NI PXIe-4353 and TB-4353 system should meet if it has been one year between calibrations. The following definitions describe how to use the information from these tables:

- **Test Point**—The voltage value that is input or output for verification purposes. This value is broken down into two columns, *Location* and *Value*. *Location* refers to where the test value fits within the test range. *Value* refers to the voltage or temperature value to be verified. Max refers to maximum value, Min refers to minimum value, and Mid refers to mid-scale.
- **1-Year Limits**—Contains the *Upper Limits* and *Lower Limits* for the test point value. That is, when the module is within its 1-year calibration interval, the test point value should fall between these upper and lower limit values.

Module Verification Test Limit Tables

Table 4. NI PXIe-4353 Analog Input Voltage Accuracy Verification Test Limits

Timing Mode	Test Point		1-Year Limits (V)	
	Location	Value (V)	Lower Limit	Upper Limit
1 (High Resolution)	Max	0.070000	0.069970	0.070030
	Min	–0.070000	–0.070030	–0.069970
2	Max	0.070000	0.069970	0.070030
	Min	–0.070000	–0.070030	–0.069970
3	Max	0.070000	0.069970	0.070030
	Min	–0.070000	–0.070030	–0.069970
4	Max	0.070000	0.069969	0.070031
	Min	–0.070000	–0.070031	–0.069969
5	Max	0.070000	0.069960	0.070040
	Min	–0.070000	–0.070040	–0.069960
6	Max	0.070000	0.069959	0.070041
	Min	–0.070000	–0.070041	–0.069959
7 (High Speed)	Max	0.070000	0.069958	0.070042
	Min	–0.070000	–0.070042	–0.069958

Table 5. NI PXIe-4353 Offset with Autozero Enabled Verification Test Limits

Timing Mode	Test Point		1-Year Limits (V)	
	Location	Value (V)	Lower Limit	Upper Limit
1 (High Resolution)	Mid	0.000000	–0.000002	0.000002
2			–0.000002	0.000002
3			–0.000002	0.000002
4			–0.000003	0.000003
5			–0.000005	0.000005
6			–0.0000065	0.0000065
7 (High Speed)			–0.0000075	0.0000075

Table 6. NI PXIe-4353 Offset with Autozero Disabled Verification Test Limits

Timing Mode	Test Point		1-Year Limits (V)	
	Location	Value (V)	Lower Limit	Upper Limit
1 (High Resolution)	Mid	0.000000	–0.0000095	0.0000095
2			–0.0000095	0.0000095
3			–0.0000095	0.0000095
4			–0.0000105	0.0000105
5			–0.000013	0.000013
6			–0.0000145	0.0000145
7 (High Speed)			–0.0000155	0.0000155

Table 7. NI PXIe-4353 CJC Resistance Accuracy Verification Test Limits

Timing Mode	Test Point		1-Year Limits (Ω)	
	Location	Value (Ω)	Lower Limit	Upper Limit
1 (High Resolution)	Max	32400	32349.6	32450.4
	Mid	10000	9987.0	10013.0
	Min	2200	2197.2	2202.8
2	Max	32400	32349.6	32450.4
	Mid	10000	9987.0	10013.0
	Min	2200	2197.2	2202.8
3	Max	32400	32349.6	32450.4
	Mid	10000	9987.0	10013.0
	Min	2200	2197.2	2202.8
4	Max	32400	32349.6	32450.4
	Mid	10000	9987.0	10013.0
	Min	2200	2197.2	2202.8
5	Max	32400	32349.6	32450.4
	Mid	10000	9987.0	10013.0
	Min	2200	2197.2	2202.8
6	Max	32400	32349.6	32450.4
	Mid	10000	9987.0	10013.0
	Min	2200	2197.2	2202.8
7 (High Speed)	Max	32400	32349.6	32450.4
	Mid	10000	9987.0	10013.0
	Min	2200	2197.2	2202.8

Where to Go for Support

The National Instruments Web site is your complete resource for technical support. At `ni.com/support` you have access to everything from troubleshooting and application development self-help resources to email and phone assistance from NI Application Engineers.

National Instruments corporate headquarters is located at 11500 North Mopac Expressway, Austin, Texas, 78759-3504. National Instruments also has offices located around the world to help address your support needs. For telephone support in the United States, create your service request at `ni.com/support` and follow the calling instructions or dial 512 795 8248. For telephone support outside the United States, visit the Worldwide Offices section of `ni.com/niglobal` to access the branch office Web sites, which provide up-to-date contact information, support phone numbers, email addresses, and current events.

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